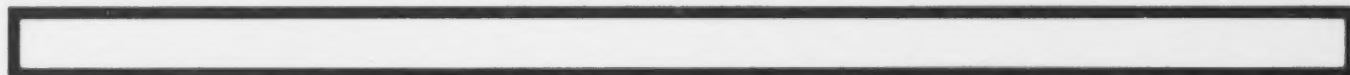


Research in a Regulatory Environment

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16. ABSTRACT The paper discusses the rationale and motivation for integrated environmental control as it relates to EPA research, particularly as it involves risk management. (NOTE: Risk management involves weighing policy alternatives and selecting the most important action based on available risk assessment and risk reduction options; risk assessment involves examining the source of pollution, how the pollution moves through the environment, how people are exposed to the pollution, and the effects of that exposure; and risk reduction involves identifying technical and management options to protect public health and the environment from the risk.) EPA research, whether in support of integrated environmental control or not, must be responsive to the Agency's regulatory function. Risk reduction programs have been successful in the past, leading to demonstration of flue gas desulfurization (FGD) and low nitrogen oxide (NOx) burner technologies. One emphasis of current risk reduction research activities is integrated environmental control because of the possibility of greater cost effectiveness. Two examples of integrated environmental control are described: limestone injection multistage burners (LIMB) and electrostatic precipitators-sulfur oxides (E-SOx). Both of these technologies show great promise for moderate to high SO2 control with very low cost and ease of retrofit.		
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RESEARCH IN A REGULATORY ENVIRONMENT

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ABSTRACT

Risk management at EPA is discussed. This is a process of selecting the most appropriate action based on performing a risk assessment and evaluation of available risk reduction options. Examples of relevant risk reduction research relating to the electric utility industry are described. Also, three recent research activities involving integrated environmental control processes are discussed. They are:

- ° Limestone Injection Multistage Burners (LIMB),
- ° The Advanced Silicate (ADVACATE) Process for Simultaneous SO₂ and NO_x Control, and
- ° Electrostatic Precipitator-Sulfur Oxides (E-SO_x) for Simultaneous SO₂ and Particle Control.

The principles of each of these processes are discussed with emphasis on integrated environmental control factors.

INTRODUCTION

In order to understand the rationale and motivation for integrated environmental control as it relates to EPA research it is first important to understand the concept of risk management. Risk management is a process of weighing policy alternatives and selecting the most important action based on available risk assessment and risk reduction options. Risk assessment is concerned with examining the source of pollution, how the pollution moves through the environment, how people are exposed to the pollution, and the effects of that exposure. Risk reduction is the identification of technical and management options to protect public health and the environment from the risk. It should be noted that risk assessment and risk reduction activities are not necessarily sequential; sometimes--often--the two overlap (1). Since risk reduction is one of EPA's major goals, the Agency faces many demands for more effective, less costly techniques to reduce risk. Risk management offers an approach for setting priorities among the risks that are amenable to control and choosing the appropriate actions to reduce those risks.

Presently, EPA priorities to a large extent respond to its Congressional mandates. Most research conducted by EPA is driven by Program Office priorities and consists mainly of support for regulatory and enforcement programs. Thus, research budgets are presently focused on meeting these Program Office needs. Little opportunity and few resources remain for a risk reduction research and development program that focuses on environmental problems beyond the current interest of the Program Offices. As a result, EPA's risk reduction research and development program is limited in scope and dictated by current near-term Program Office priorities.

EXAMPLES OF SUCCESSFUL RISK REDUCTION RESEARCH

EPA's risk reduction research is conducted primarily by its Office of Environmental Engineering and Technology Demonstration (OEETD) within the Office of Research and Development (ORD). These risk reduction research activities include:

- 1) support for the development and implementation of regulations;
- 2) development, improvement, and demonstration of control technologies;
- 3) research of fundamental processes pertaining to pollution control; and
- 4) technology transfer and technical assistance.

While OEETD has undertaken risk reduction research in response to regulatory needs, it has also conducted research mindful of providing good fundamental data and of conceiving innovative solutions, as in the development of flue gas desulfurization (FGD) and low nitrogen oxide (NO_x) combustion technologies. The paragraphs below discuss first the FGD and then the NO_x programs.

EPA initiated a research program in FGD in the mid 1960s. The in-house program performed a major role in establishing the fundamental mechanisms of wet scrubbing of sulfur dioxide (SO_2) with lime, limestone, and other alkali materials. EPA also participated in pilot-scale development and full-scale demonstration of a number of FGD systems. These demonstrations and other work contributed to the establishment of New Source Performance Standards (NSPS) for SO_2 control on coal-fired utility boilers. Building on this expertise, EPA pioneered the use of organic acids in limestone scrubbers for improved SO_2 capture and for more reliable system operation. This technology was developed from fundamental data, through pilot scale, and subsequently demonstrated on industrial and coal-fired utility boilers. This technique is currently commercialized and frequently used to improve the performance of either existing or new FGD systems.

EPA's ORD conducted a coordinated in-house and extramural research program in low NO_x technology to accomplish the following:

- 1) establish the fundamental mechanisms and rates of conversion of fuel nitrogen to NO_x ;
- 2) quantify the evolution of fuel nitrogen and its conversion by fuel type;
- 3) evaluate the most effective combustion process modifications for each fuel type;
- 4) develop mathematical models of the chemical processes involved;
- 5) test low NO_x burner concepts at the pilot scale; and
- 6) demonstrate the low NO_x concentric firing system (LNCFS) for tangentially fired boilers and a low NO_x burner for wall-fired boilers.

EPA's low NO_x combustion research helped to reduce the threat to human health and the environment from NO_x releases from boilers and furnaces. This research also encouraged the private sector to work with the Agency in cooperative testing of other privately developed low NO_x burners. EPA's broad expertise, based on long-term research in this area, assisted EPA in establishing regulatory standards for NO_x , as well as other pollutants, from a range of sources.

RISK REDUCTION APPLIED TO INTEGRATED ENVIRONMENTAL CONTROL

As noted in the introduction, the Agency faces many demands for more effective, less costly techniques to reduce risk. The simultaneous control of a combination of pollutants offers such a technique. Also, from a risk management point of view, it makes no sense to simply change a risk from one form to another--from an air problem to a water or a solid waste problem. This moves a risk around without solving the problem. Consequently, there is an emphasis on integrated environmental control (IEC) which aims at minimizing waste production. As examples of risk reduction applied to IEC, two processes will be discussed:

- 1) Limestone Injection Multistage Burners (LIMB) combined with the Advanced Silicate (ADVACATE) process for simultaneous SO_2 and NO_x control; and
- 2) Electrostatic Precipitator-Sulfur Oxides (E- SO_x) for simultaneous SO_2 and particulate control.

LIMB COMBINED WITH ADVACATE

The LIMB process is an IEC for SO_2 and NO_x using limestone injection for SO_2 control and multistage burners for NO_x abatement. The ADVACATE process is an SO_2 control technique which can be used alone or in combination with another process with the advantage of greatly reducing the waste from the first process. A further description of both the LIMB and ADVACATE processes follows.

The heart of the LIMB process is the injection of a calcium based sorbent into the high temperature zone (2300°F) of the furnace of the utility boiler system (see Figure 1). At high temperatures, the sorbent quickly changes to calcium oxide which reacts with SO_2 to form calcium sulfate

which is very insoluble and environmentally compatible. The calcium sulfate and fly ash travel through the system to the electrostatic precipitator (ESP) where they are both captured. As part of the LIMB process, a humidifier in front of the ESP improves performance of the ESP and provides additional SO_2 capture at low temperature. Results from a 100 MWe full scale demonstration at the Edgewater station of Ohio Edison show at least a 50 to 60% reduction of SO_2 in the furnace (see Figures 2 and 3) at a calcium to sulfur ratio of 2. A minimum of 60 to 70% SO_2 capture is expected overall with humidification. Also part of the LIMB system, low NO_x burners are installed in the furnace, and results from the full scale demonstration show a 50% reduction in NO_x . Other equipment necessary for the LIMB system consists of the sorbent receiving, handling, and injection subsystems.

The heart of the ADVACATE process is a pressure hydrator which converts fly ash and lime into a moist powder with very high surface area (up to $50 \text{ m}^2/\text{g}$) and consequently high reactivity. Because of the high surface area, the powder can be moist (up to 30% moisture) but still flow like dry powder. Upon injection into a low temperature zone of a flue gas stream (200°F), the powder shows the ability to collect 50 to 90% of the SO_2 because of its high surface area and because the moisture promotes the powder and the reaction conditions. Other equipment needed by the ADVACATE process includes materials handling and injection subsystems and a means (humidifier or heat exchanger) to cool the flue gas stream.

The combination of LIMB and ADVACATE is especially attractive because the LIMB system provides the humidifier that ADVACATE needs, and the ADVACATE system provides a use for the unreacted lime produced by the LIMB system (thus, reducing the solid waste and increasing the overall utilization of the calcium based sorbent). The combination is a natural because the input needed by ADVACATE (which is fly ash and lime) is exactly the material leaving the furnace using LIMB. In practice, the material taken from the bottom of the ESP becomes the input to the pressure hydrator of the ADVACATE process which injects between the LIMB system humidifier and the ESP. Moreover, the combination provides at least 80% SO_2 collection efficiency.

E-SO_x COMBINED WITH LOW NO_x BURNERS

Control of both SO₂ and particulate matter is achievable with E-SO_x (see Figure 4). The E-SO_x process is a way to use an old ESP housing to contain both SO₂ and particulate control because of improvements to the latter. Typically, an old ESP has three control areas or fields in the direction of gas flow. Advances in ESP technology make it possible to achieve more than the old particulate control in two thirds of the volume (or in only two fields). If this is accomplished in the last two fields, the volume formerly occupied by the first field can be used for retrofitting a dry scrubber for SO₂ control. This is especially advantageous at sites with limited space for retrofitting SO₂ control equipment and saves on the cost of a vessel for a dry scrubber.

The major advance in ESP technology which makes this concept possible is the development of the two-stage ESP which was the result of EPA's attention to fundamentals and innovative problem solving. For an ESP to collect particulate matter, it must first charge the particles and then move them to the collecting plate. In an ordinary ESP, both of these steps take place in the same volume. Unfortunately, optimum conditions for charging are not optimum for collection; therefore, compromise conditions must be used. The two-stage ESP uses separate volumes for charging and for collection, allowing each to be optimized. Actually, the concept of a two-stage ESP is not new; what makes it work is the innovative charging section conceived by EPA. Called the cold-pipe precharger, this concept avoids unfavorable electrical conditions by cooling the grounded electrode in the charging section. This breakthrough permits adequate particulate control in a much smaller ESP.

The SO₂ control in E-SO_x relies on the injection of water droplets containing an alkali (usually slaked or hydrated lime). The critical parameters are the droplet size and the lime particle size. If the droplets are too small, they will evaporate quickly, before removing enough SO₂. If the droplets are too large, wet drops will be carried into the ESP part of E-SO_x where the moisture will create problems. The lime particles must be as small as possible to provide rapid availability of alkali. Because of EPA's expertise in FGD, as noted above, these problems are well understood, and the E-SO_x process is on track to demonstration.

CONCLUSIONS

Research at EPA, whether in support of integrated environmental control or not, must be responsive to the regulatory function of the Agency. Because of the heavy demand upon EPA for programs to protect human health and the environment, the relative importance of programs is determined by the process of risk management. Risk management consists of risk assessment and risk reduction, both of which may often have to be executed in parallel. Risk reduction programs have been successful in the past, leading to demonstration of flue gas desulfurization and low NO_x burner technologies. One emphasis of current risk reduction research activities is integrated environmental control because of the possibility of greater cost effectiveness. Two examples of integrated environmental control were described; namely, LIMB and E- SO_x . Both of these technologies show great promise for moderate to high SO_2 control with very low cost and ease of retrofit. Currently, results from the LIMB demonstration show reductions in NO_x of 50% and in-furnace captures of SO_2 of at least 50 to 60%, with no adverse impact on operation of the furnace of the utility boiler. Capture of SO_2 will be higher across the whole system because of low temperature capture in the LIMB humidifier and in the optional ADVACATE add-on. The significance of these results is that the flexibility of SO_2 , NO_x , and acid rain control is greatly increased and especially older power plants and those with low load factors are cost-effectively controlled. This in turn reduces risk of acid gases to human health and the environment.

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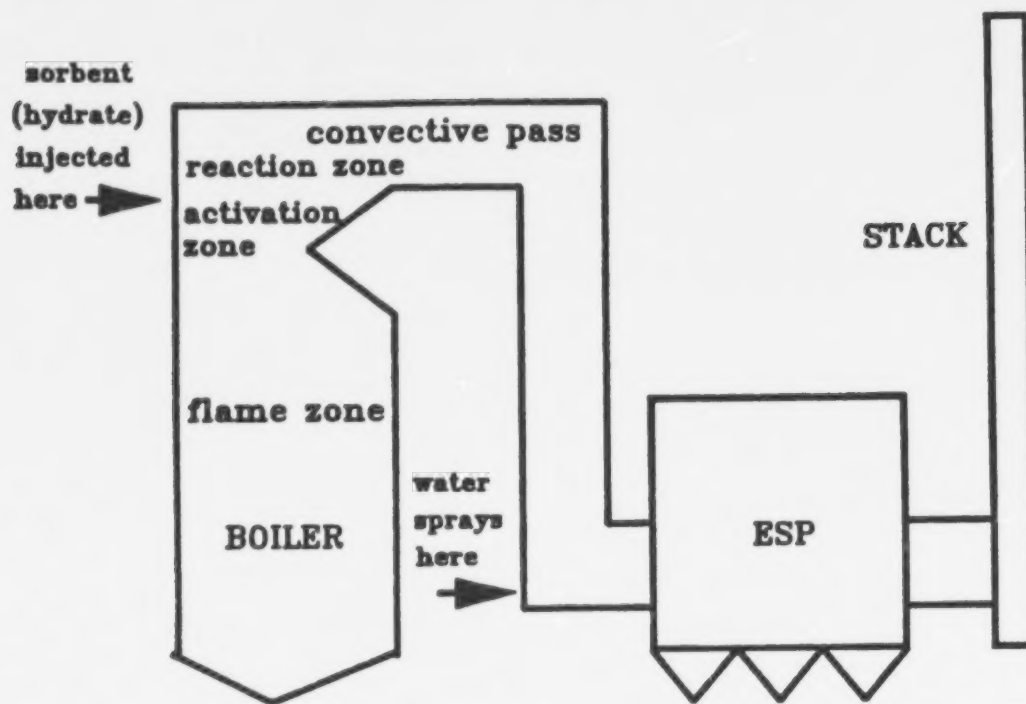


FIGURE 1. THE LIMB PROCESS.

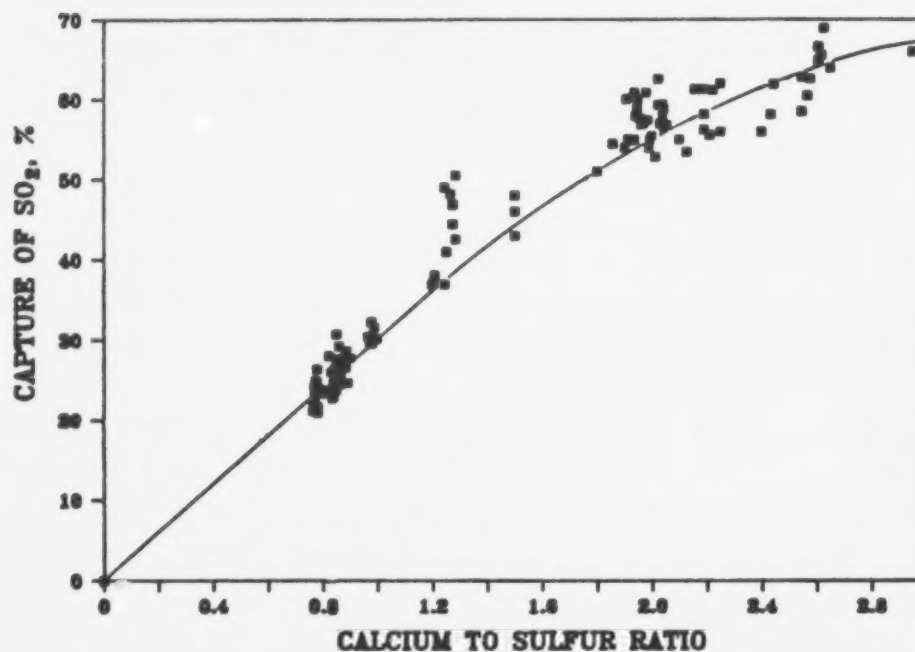


FIGURE 2. RESULTS FROM THE EDGEWATER DEMONSTRATION.

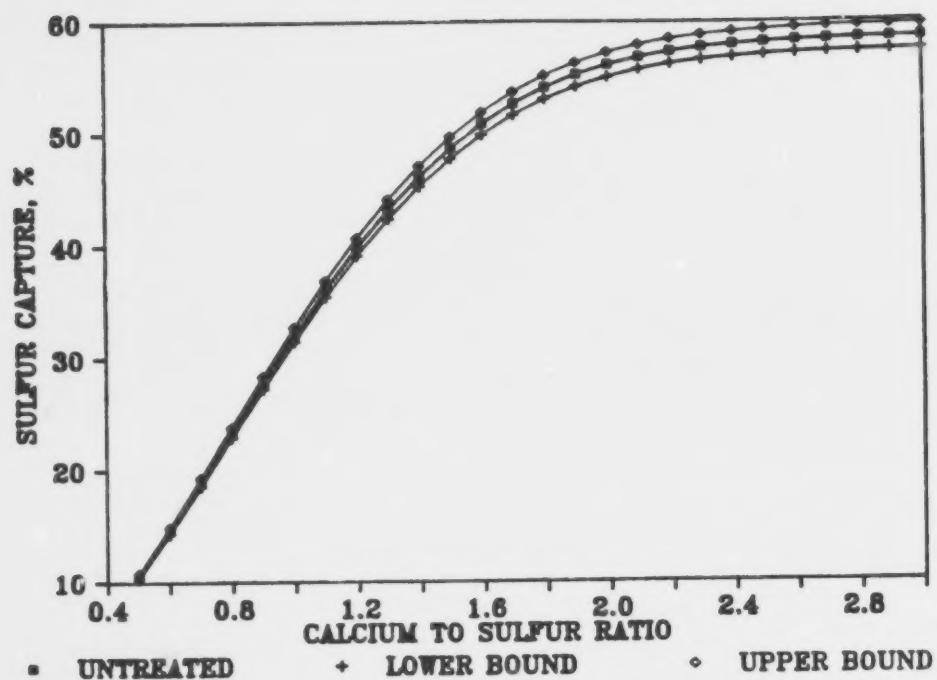


FIGURE 3. STATISTICAL FIT FOR UNTREATED SORBENT ILLUSTRATING THE 2 SIGMA ERROR BAND.

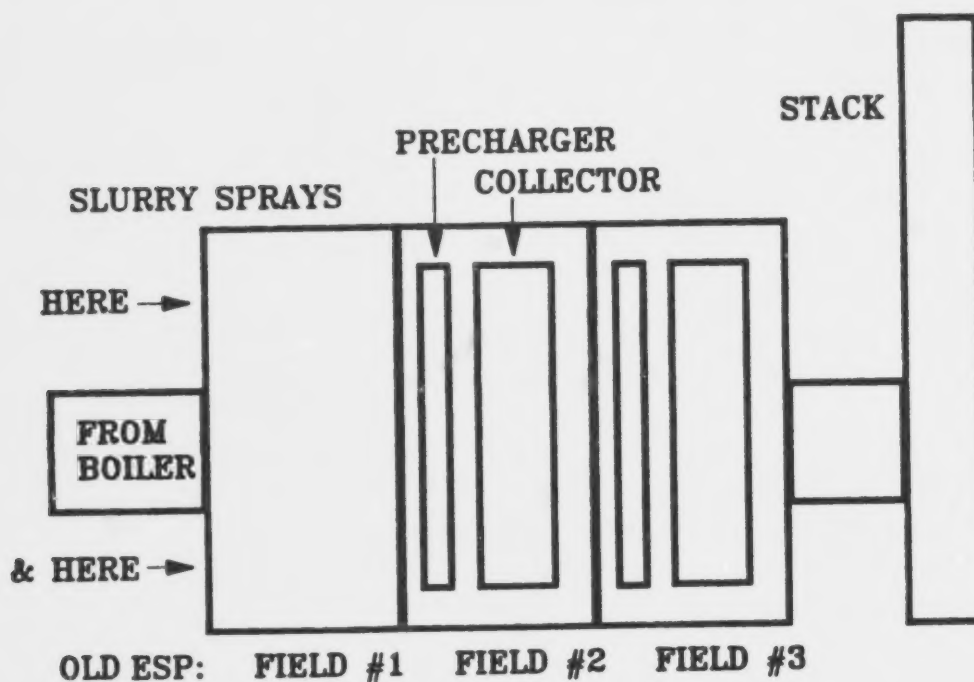


FIGURE 4. E-SO₂ RETROFIT.